What is claimed is

1. A face detection and tracking system for detecting and tracking a plurality of faces in real time from an input image, the system comprising:

a background removing unit which extracts an area having a motion by removing the background image from the input image;

a candidate area extracting unit which extracts a candidate area in which a face is possibly located in the area having a motion, by using a skin color probability map (P_{skin}) generated from a face skin color model and the global probability map (P_{global});

a face area determination unit which extracts independent component analysis (ICA) features from a candidate area and determines whether or not the candidate area is a face area; and

a face area tracking unit which tracks a face area according to a directional kernel indicating a probability that a face is located in a next frame, based on the skin color probability map.

2. The system of claim 1, wherein the candidate area extracting unit comprises:

a skin color probability map generation unit which generates a skin color probability map (P_{skin}) of the area having a motion, by using a face skin color model;

a global probability map generation unit which extracts a plurality of highest points of the area having a motion, sets central coordinates at a predetermined distance from the plurality of highest points, and calculates a probability that a face is located within a distance from the central coordinates, to generate a global probability map (P_{global}); and

a multiple scale probability map generation unit which generates a multiple scale probability map about the probability that a face is located, by multiplying the skin color probability map and the global probability map (P_{global}), and extracts an area, in which the probability value of the generated multiple scale probability map is equal to or greater than a predetermined threshold

value, as a candidate area where a face is possibly located.

3. The system of claim 2, wherein the skin color probability map generation unit converts the color of each pixel in the area having a motion into hue and saturation values, and applies the values to a face skin color model which is a 2-dimensional Gaussian model that is trained in advance with a variety of skin colors, to generate a skin color probability map indicating a probability that the color of an area having a motion is a skin color.

4. The system of claim 3, wherein when Hue(i,j) and Sat(i,j) denote the hue and saturation at coordinates (i,j) of the area having a motion, respectively, $\vec{u}$ and denote the average and distribution of Gaussian dispersion, respectively, and the size of a face desired to be searched for is n, the skin color probability map $P_{skin}(x,y,n)$ is generated according to the following equation:

$$P_{skin}(x,y,n) = \frac{\sum_{i=x-n/2}^{i=x+n/2} \sum_{j=y-n/2}^{j=y+n/2} g(Hue(i,j), Sat(i,j); \vec{u}, \Sigma)}{n^2}$$

5. The system of claim 2, wherein when $\vec{u}_i$ denotes the central coordinates of the candidate area, denotes a dispersion matrix, n denotes the size of a face area, and (x_i,y_i) denotes the coordinates of each local area (i), the global probability map generation unit generates global probability map P_{global} (x,y,n) according to the following equation:

$$P_{global}(x,y,n) = \sum_{i=1}^{N} g(x_i, y_i; \vec{u}_i, \Sigma)$$

where $\vec{u}_i$, , x_i, and y_i satisfies the following equations, respectively:

$$\vec{u}_i = \begin{pmatrix} u_{ix} \\ u_{iy} \end{pmatrix} = \begin{pmatrix} m_{ix} + n\cos(\angle(-\vec{n}(m_i))) \\ m_{iy} + n\sin(\angle(-\vec{n}(m_i))) \end{pmatrix}, \quad \Sigma = \begin{pmatrix} n^2 & 1.5n^2 \\ 1.5n^2 & (1.5n)^2 \end{pmatrix}.$$

$$\begin{pmatrix} x_i \\ y_i \end{pmatrix} = \begin{pmatrix} \cos(\angle(\vec{n}(m_i)) & -\sin(\angle(\vec{n}(m_i)) \\ \sin(\angle(\vec{n}(m_i)) & \cos(\angle(\vec{n}(m_i)) \end{pmatrix} \cdot \begin{pmatrix} x - u_{ix} \\ y - u_{iy} \end{pmatrix}$$

6. The system of claim 1, wherein the face area determination unit comprises:

an ICA feature extracting unit which extracts features by performing ICA on the extracted face candidate area; and

a face determination unit which determines whether or not the candidate area is a face, by providing the ICA features of the candidate area to a support vector machine (SVM) which has learned features obtained by performing ICA on learning face images and features obtained by performing ICA on images that are not a face.

7. The system of claim 1, wherein when it is assumed that the coordinates at which the center of a face is to be located, and the dispersion are (μ_x, μ_y) and (σ_x,σ_y), respectively, and $\bar{\sigma}_x^2 = 2(\sigma_x^2 + \Delta\mu_x^2)$, $\bar{\sigma}_y^2 = 2(\sigma_y^2 + \Delta\mu_y^2)$, $Z_x = \frac{x-\mu_x}{\sigma_x}, Z_y = \frac{x-\mu_y}{\sigma_y}$, if the probability that a face is located is $f(x,y,\sigma_x,\sigma_y) = \frac{1}{S} \cdot \exp\left\{\frac{-(Z_x^2 - 2\sigma_{xy} Z_x Z_y + Z_y^2)}{2(1-\sigma_{xy}^2)}\right\}$, the direction kernel is expressed as $f(x, y, \sigma_x, \sigma_y)$ in the direction in which the face area moves, and expressed as $f(x, y, \bar{\sigma}_x, \bar{\sigma}_y)$ in the opposite direction.

8. The system of claim 1, wherein the background removing unit obtains a first area which is not a background, by using the brightness difference of the input image and a background image stored in advance, and

obtains a second area which is not the background, by using the color difference of the two images, and among a plurality of sub-areas included in the second area that is not the background, and extracts each sub-area which includes the center of a sub-area included in the first area that is not the background, as areas that are not background, to remove the background image from the input image and extract an area having a motion.

9. The system of claim 8, wherein the background removing unit updates a new background image R'(x,y) according to the following equation:

$$R'(x,y) = \beta R(x,y) + (1-\beta)B(x,y)$$

where R(x,y) denotes an existing background image, B(x,y) denotes a binary image in which an area having a motion is removed form the input image, and β denotes an update constant.

10. A face detection and tracking system for detecting and tracking a plurality of faces in real time from an input image, the system comprising:

a background removing unit which obtains a first area which is not a background, by using the brightness difference of an input image and a background image stored in advance, and obtains a second area which is not the background, by using the color difference of the two images, and among a plurality of sub-areas included in the second area that is not the background, and extracts each sub-area which includes the center of a sub-area included in the first area that is not the background, as areas that are not background, to remove the background image from the input image and extract an area having a motion;

a skin color probability map generation unit which generates a skin color probability map (P_{skin}) of the area having a motion, by using a face skin color model;

a global probability map generation unit which extracts a plurality of highest points of the area having a motion, sets central coordinates at a predetermined distance from the plurality of highest points, calculates a probability that a face is located within a predetermined distance from the central coordinates, to generate global probability map (P_{global})

a multiple scale probability map generation unit which generates a multiple scale probability map about the probability that a face is located, by multiplying the skin color probability map and the global probability map (P_{global}), and extracts an area, in which the probability value of the generated multiple scale probability map is equal to or greater than a predetermined threshold value, as a candidate area where a face is possibly located;

a face area determination unit which extracts independent component analysis (ICA) features from a candidate area and determines whether or not the candidate area is a face area, by providing the ICA features of the candidate area to a support vector machine (SVM) which has learned features obtained by performing ICA on learning face images and features obtained by performing ICA on images that are not a face; and

a face area tracking unit which tracks a face area according to a directional kernel indicating a probability that a face is located in a next frame, based on the skin color probability map.

11. A face detection and tracking method for detecting and tracking a plurality of faces in real time from an input image, the method comprising:

(a) extracting an area having a motion by removing the background image from the input image;

(b) extracting a candidate area in which a face is possibly located in the area having a motion, by using a skin color probability map (P_{skin}) generated from a face skin color model and the global probability map (P_{global});

(c) extracting independent component analysis (ICA) features from a candidate area and determining whether or not the candidate area is a face area; and

(d) tracking a face area according to a directional kernel indicating a probability that a face is located in a next frame, based on the skin color probability map.

12. The method of claim 11, wherein step (b) comprises:

(b1) generating a skin color probability map (P_{skin}) of the area having a motion, by using a face skin color model;

(b2) extracting a plurality of highest points of the area having a motion, setting central coordinates at a predetermined distance from the plurality of highest points, and calculating a probability that a face is located within a predetermined distance from the central coordinates, to generate a global probability map (P_{global}); and

(b3) generating a multiple scale probability map about the probability that a face is located, by multiplying the skin color probability map and the global probability map (P_{global}), and extracting an area, in which the probability value of the generated multiple scale probability map is equal to or greater than a predetermined threshold value, as a candidate area where a face is possibly located.

13. The method of claim 12, wherein in step (b1) the color of each pixel in the area having a motion is converted into hue and saturation values and the values is applied to a face skin color model which is a 2-dimensional Gaussian model that is trained in advance with a variety of skin colors, to generate a skin color probability map indicating a probability that the color of an area having a motion is a skin color.

14. The method of claim 13, wherein when Hue(i,j) and Sat(i,j) denote the hue and saturation at coordinates (i,j) of the area having a motion, respectively, $\vec{u}$ and denote the average and distribution of Gaussian dispersion, respectively, and the size of a face desired to be searched for is n, the skin color probability map $P_{skin}(x,y,n)$ is generated according to the following

equation:

$$P_{skin}(x,y,n) = \frac{\sum_{i=x-n/2}^{i=x+n/2}\sum_{j=y-n/2}^{j=y+n/2} g(Hue(i,j), Sat(i,j); \vec{u}, \Sigma)}{n^2}$$

15. The method of claim 12, wherein in step (b2), when $\vec{u}_i$ denotes the central coordinates of the candidate area, denotes a dispersion matrix, n denotes the size of a face area, and (x_i,y_i) denotes the coordinates of each local area (i), global probability map P_{global} (x,y,n) is generated according to the following equation:

$$P_{global}(x,y,n) = \sum_{i=1}^{N} g(x_i, y_i; \vec{u}_i, \Sigma)$$

where $\vec{u}_i$, , x_i, and y_i satisfies the following equations, respectively:

$$\vec{u}_i = \begin{pmatrix} u_{ix} \\ u_{iy} \end{pmatrix} = \begin{pmatrix} m_{ix} + n\cos(\angle(-\vec{n}(m_i))) \\ m_{iy} + n\sin(\angle(-\vec{n}(m_i))) \end{pmatrix}, \ \Sigma = \begin{pmatrix} n^2 & 1.5n^2 \\ 1.5n^2 & (1.5n)^2 \end{pmatrix}.$$

$$\begin{pmatrix} x_i \\ y_i \end{pmatrix} = \begin{pmatrix} \cos(\angle(\vec{n}(m_i)) & -\sin(\angle(\vec{n}(m_i)) \\ \sin(\angle(\vec{n}(m_i)) & \cos(\angle(\vec{n}(m_i)) \end{pmatrix} \cdot \begin{pmatrix} x - u_{ix} \\ y - u_{iy} \end{pmatrix}$$

16. The method of claim 11, wherein step (c) comprises:

extracting features by performing ICA on the extracted face candidate area; and

determining whether or not the candidate area is a face, by providing the ICA features of the candidate area to a support vector machine (SVM) which has learned features obtained by performing ICA on learning face images and features obtained by performing ICA on images that are not a face.

17. The method of claim 11, wherein when it is assumed that the coordinates at which the center of a face is to be located, and the dispersion are (μ_x, μ_y) and (σ_x,σ_y), respectively, and $\overline{\sigma}_x^2 = 2(\sigma_x^2 + \Delta\mu_x^2)$, $\overline{\sigma}_y^2 = 2(\sigma_y^2 + \Delta\mu_y^2)$, $Z_x = \frac{x-\mu_x}{\sigma_x}, Z_y = \frac{x-\mu_y}{\sigma_y}$, if the probability that a face is located is $f(x,y,\sigma_x,\sigma_y) = \frac{1}{S} \cdot \exp\left\{\frac{-(Z_x^2 - 2\sigma_{xy}Z_xZ_y + Z_y^2)}{2(1-\sigma_{xy}^2)}\right\}$, the direction kernel is expressed as $f(x, y, \sigma_x, \sigma_y)$ in the direction in which the face area moves, and expressed as $f(x, y, \overline{\sigma}_x, \overline{\sigma}_y)$ in the opposite direction.

18. The method of claim 11, wherein in step (a), a first area which is not a background is obtained by using the brightness difference of the input image and a background image stored in advance, and a second area which is not the background is obtained by using the color difference of the two images, and among a plurality of sub-areas included in the second area that is not the background, each sub-area, which includes the center of a sub-area included in the first area that is not the background, is extracted as an area that is not the background, so that the background image is removed from the input image and an area having a motion is extracted.

19. The method of claim 18, wherein in step (a), a new background image R'(x,y) is updated according to the following equation:

$$R'(x,y) = \beta R(x,y) + (1-\beta)B(x,y)$$

where R(x,y) denotes an existing background image, B(x,y) denotes a binary image in which an area having a motion is removed form the input image, and β denotes an update constant.

20. A face detection and tracking method for detecting and tracking a plurality of faces in real time by combining visual information of an input image,

the method comprising:

obtaining a first area which is not a background by using the brightness difference of an input image and a background image stored in advance, and obtaining a second area which is not the background, by using the color difference of the two images, and among a plurality of sub-areas included in the second area that is not the background, and extracting each sub-area which includes the center of a sub-area included in the first area that is not the background, as areas that are not background, to remove the background image from the input image and extract an area having a motion;

generating a skin color probability map (P_{skin}) of the area having a motion, by using a face skin color model;

extracting a plurality of highest points of the area having a motion, setting central coordinates at a predetermined distance from the plurality of highest points, and calculating a probability that a face is located within a predetermined distance from the central coordinates, to generate global probability map (P_{global});

generating a multiple scale probability map about the probability that a face is located, by multiplying the skin color probability map and the global probability map (P_{global}), and extracting an area, in which the probability value of the generated multiple scale probability map is equal to or greater than a predetermined threshold value, as a candidate area where a face is possibly located, to generate a multiple scale probability map;

extracting independent component analysis (ICA) features from a candidate area and determining whether or not the candidate area is a face area, by providing the ICA features of the candidate area to a support vector machine (SVM) which has learned features obtained by performing ICA on learning face images and features obtained by performing ICA on images that are not a face; and

tracking a face area according to a directional kernel indicating a probability that a face is located in a next frame, based on the skin color probability map.

21. A computer readable medium having embodied thereon a computer program for the method of claim 11.